Evaluation of tinnitus perception vs. tinnitus-evoked negative reactions in human and animal studies

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Currently, there is no method which would allow to detect even tinnitus perception in human in objective manner. However, even when a method is developed to detect the presence of tinnitus it will not address the issue whether tinnitus is bothersome. Note, that about 80% of all people experiencing tinnitus do not have any problem with it and that psychoacoustical characterization of tinnitus, i.e., its pitch, loudness and minimal masking levels are not related to tinnitus severity. Furthermore, all questionnaires to evaluate tinnitus severity do not protect against malingering and it is easy for a subject to pretend having high level of tinnitus severity. Thus, there is significant need for developing a method which would allow to assess tinnitus severity in human in an objective manner. The issue is of particular significance in situation when a compensation is provided for tinnitus, e.g. Veteran Administration or Workers Compensation.

Typically, animal models are providing directions for human studies. Unfortunately, all existing animal models are strictly focused on detection of tinnitus perception and potentially on evaluation of tinnitus pitch. While work is going on toward creating an animal model evaluating tinnitus-evoked negative reactions, so far such a model is still in development.

An approach is proposed, which may allow to assess tinnitus severity in humans in an objective manner. First, the perceived tinnitus sound is reconstructed. Second, a psychological measure (e.g., fMRI, PET, EEG, reactions of the autonomic system) is recorded in response to this reconstructed tinnitus sound and to the sound which is modified to decrease its similarity to the tinnitus (e.g., by shifting its spectrum). Third, the difference in response to these two signals is correlated with tinnitus severity, psychoacoustical characterization of tinnitus and properties of the auditory system (e.g, hearing threshold and loudness discomfort levels). The differences in responses to original tinnitus sound and its frequency shifted version, which are correlated with tinnitus severity, but not with other psychoacoustical parameters, would indicate that this particular measure (e.g., activation of a specific brain area as revealed by fMRI) is linked to tinnitus severity. Once this measure (e.g., activation of specific brain area) is shown to be related to tinnitus severity, but not to tinnitus perception, then it can be

used on clinical subjects to estimate the severity of tinnitus in the particular subject. Alternatively, the measure which has been shown to be related to tinnitus perception alone (i.e., correlation of the physiological measure with psychoacoustical characterization of tinnitus, but not with tinnitus severity) can be utilized to show that a given subject perceives tinnitus, but does not have problems with it.

The results of a fMRI study designed to follow the outlined above reasoning will be presented. They fully support the approach proposed and indicated that the activation of Brodmann's areas 8, 21 and 24 (the anterior cingulate cortex) seems to be related to tinnitus severity and potentially can be used for assessing tinnitus severity in an objective manner. Notably, this general approach can be used for any physiological measurements which could be more economically viable and faster to perform.